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Pompeo Della Posta and Roberto Tamborini

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Dipartimento di Economia e Management

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The existential trilemma of EMU in a model of fiscal target zone

Pompeo Della Posta[a]   Roberto Tamborini[b]

Abstract

The lesson of the sovereign debt crises of the 2010s, and of the outbreak of the COVID-19 pandemic is that EMU irreversibility, if not to remain a wishful statement in the founding treaties, necessitates to be completed by carefully designed ramparts for extraordinary times beside regulations for ordinary times. In this paper we wish to contribute to this line of thought in two points. First, we highlight that when exposed to large, systemic shocks the EMU faces a trilemma: its integrity can only be saved by relaxing either monetary orthodoxy, or fiscal orthodoxy, or both. We elaborate this concept by means of a fiscal target-zone model, where EMU member governments are willing to abide with the commitment to debt stability under the no-bailout clause only up to an upper bound of their feasible fiscal effort. Second, we show that EMU completion means providing a monetary and/or fiscal emergency backstop to the irreversibility principle. Drawing on the target-zone literature, we show how these devices can be designed in a consistent manner that minimises their extension and mitigates the moral hazard concerns. The alternative to these devices is not retaining both the EMU irreversibility and the twin orthodoxies, but reformulating the treaties with explicit and regulated exit procedures.

Keywords: COVID-19 pandemic, Fiscal Target Zone, Public Debt, Speculative Attacks, Fiscal Orthodoxy, Monetary Orthodoxy.

JEL Codes: E65, F34, F36

[a]Department of Economics and Management, University of Pisa, pompeo.della.posta@unipi.it
[b]Department of Economics and Management, University of Trento, roberto.tamborini@unitn.it

1. Introduction

The conversion rate between the euro and the national currency of a country accessing the EMU is said to be "irrevocably fixed". More generally, the memberships of the European Economic and Monetary Union (EMU), as well as of the European Union (EU), have been conceived, and are regarded *de facto*, as irreversible.[1] Nonetheless, human institutions may turn out not to be irreversible, beyond good will. The balance among ideal, social, political, economic motivations and interests may turn from favourable to unfavourable. As political economists would put it, institutions should pass the test of cost-benefit analysis by members. The institutions of European integration make no exception.[2]

After remarkably prolonged honeymoon, this awareness has gained strength over the last decade. Two are, to say the least, the catalytic episodes. For the EU as a whole, one is obviously "Brexit", the United Kingdom's leave. The other, for the EMU in particular, is the swarm of sovereign debt crises after 2010, when movements of "exiters" gained voice and political momentum across the EMU (not only in ailing countries), while institutions themselves were no longer able to contain gusts of temporary separations, or outright divorces.[3]

The lesson of these events is that EMU membership irreversibility, and hence EMU integrity, if not to remain a wishful statement in the founding treaties, necessitates carefully designed ramparts for extraordinary times beside regulations for ordinary times. In this view, there is now wide agreement among independent scholars and institutional bodies that the EMU was built "incomplete", and it has remained incomplete in spite of the frantic fixes put together in the course of the crisis.[4] Here we wish to contribute to this line of thought in two points.

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[1] "Unlike the conditions for accession to the EU, which are addressed, even if not exhaustively, in Article 49 TEU11, neither the founding treaties (…), nor the successive amending treaties made until the ratification of the Lisbon Treaty, made any provision for a Member State's withdrawal (negotiated or unilateral) from the EU or EMU" (Athanassiou 2009).

[2] See e.g. Alesina et al. (1995, 2005), Spolaore (2013), Andreozzi and Tamborini (2019). The cost-benefit approach to monetary unions has been playing a central role ever since the theory of Optimum Currency Areas (Kenen 1995). Ultimately, "member states have to be better off inside than they would be outside" (Draghi 2014). As Bilbie et al. (2021) put it bluntly, "we do not think that in the long-run a eurozone can be based on anything other than self-interest" (p. 79).

[3] Well before "Brexit", the ghost of "Grexit", and possibly of other countries under debt attack, materialised with the 'No' in the 2015 Greek referendum on the conditionality of debt restructuring agreed by the Tsipras government with the so-called "Troika" formed by International Monetary Fund, European Commission and European Central Bank. Some empirical research on the determinants of spreads during the sovereign debt crisis has found evidence of nonzero breakup probability under the form of so-called "redenomination risk". That is to say the risk that, as a consequence of breakup, a country redenominates its debt in the new national currency heavily depreciated against the euro thus causing a large capital account loss for foreign debt holders (Di Cesare et al. 2012, De Santis 2015)

[4] At the level of EU institutional bodies one may recall the "Five Presidents Report" (Juncker et al. 2015), the *White Paper about the future of the EU* (European Commission 2017a), the *Reflection Paper on the*

In the first place, EMU integrity in its original conception rests on the twin orthodoxies of monetary independence and fiscal discipline, established and articulated in the Maastricht Treaty and the Stability and Growth Pact (SGP) with subsequent modifications. The twin orthodoxies, often integrated in the so-called "no bailout clause", mean to member governments neither direct lending or debt monetisation by the European Central Bank (ECB), nor fiscal transfers across governments. The sovereign debt crises of the 2010s, and the outbreak of the COVID-19 pandemic have shown that when exposed to large, systemic shocks the EMU faces a trilemma: *its integrity can only be saved by relaxing either monetary orthodoxy, or fiscal orthodoxy, or both*. The crisis of the 2010s was painfully overcome by some relaxation of monetary orthodoxy *vis-à-vis* tightening of fiscal orthodoxy.[5] By contrast, it is widely agreed that, after some initial hesitation, the reaction to the pandemic shock has been stronger, faster, and most importantly, on both the monetary and fiscal side, where the "unorthodox" innovations contained in the "Next Generation EU" Programme figure prominently. In section 2 we elaborate the EMU trilemma by means of a fiscal target-zone (TZ) model where EMU member governments are willing to abide with the commitment to debt stability under the twin orthodoxies only up to an upper bound of their feasible fiscal effort (measured by the ratio to GDP of the primary surplus), beyond which the government values the costs of compliance larger than those of breakup. Public debt can be hit by random shocks which, if large enough, push the stabilisation fiscal effort beyond the feasibility constraint.[6]

We find some support to the idea of fiscal TZ, as a stylised representation of debt management in the EMU, in Figure 1, which reproduces the band between the highest and the lowest level of public debt-to-GDP ratio, centred on the ratio of the EMU as a whole, from 1999 to 2021. These data suggest that public debt has gone through three phases: 1999-2008, 2009-19, 2020-21. During each phase, the debt band has shown substantial stability, with no evident drifts. Each change of phase corresponds to major external shocks, the Global financial crisis and Great recession in 2009, and the COVID-19 pandemic in 2020, with a "jump" into a higher, yet stable, band after the shocks. This pattern is clearer if Greece is excluded as the single country that "trespassed the band" and fell into a partial default procedure.

Deepening of the Economic and Monetary Union (European Commission 2017b), and the subsequent *Roadmap for Deepening the Economic and Monetary Union* (European Commission 2017c).

[5] Whether, and the extent to which, monetary orthodoxy was relaxed was, and still is, highly debated. Yet, no doubt, there was large and unprecedented recourse to "unconventional policies" including purchases of sovereign bonds on secondary markets which, though practiced by other central banks, conflicted with well established interpretations of the ECB's mandate (see e.g. Brunnermeier et al. 2016, Part III; Schnabel 2020a). On the fiscal side, the regulatory tightening is documented by the new dispositions known as Six Pack, Two Pack, and Fiscal Compact.

[6] The application of exchange-rate TZ models to the case of speculative attacks on public debt in the EMU has been proposed for the first time by Della Posta (2018, 2019).

[Figure 1]

In the second place, in this framework we show in section 3 that EMU completion means providing a monetary and/or fiscal emergency backstop to the irreversibility principle. Drawing on the target-zone literature, we show how these devices can be designed in a consistent manner that minimises their extension and mitigates the moral hazard concerns. The alternative to these devices is not retaining both the EMU irreversibility and the twin orthodoxies, but reformulating the treaties with explicit and regulated exit procedures. Section 4 summarises and concludes.

2. The model

The evolution of public debt as a ratio to GDP, b (henceforth public debt), is driven by a set of fundamentals and a stochastic component represented in the following continuous-time dynamic equation:

(1) $$db_t = -(s_t + m_t + f_t)dt + (r_t - g_t)b_t dt + \sigma dz$$

where the fundamentals on right-hand side are, at any moment t, the GDP ratio of the public sector's primary balance s_t (with $s_t > 0$ denoting a surplus), the GDP ratio of the monetization of public debt m_t (in the forms to be specified subsequently), exogenous net fiscal transfers f_t (e.g. the possibility for the government to receive fiscal support from other governments). The term $(r_t - g_t)b_t$ is the contribution to db_t resulting from the interest rate r_t, net of the rate of growth of GDP g_t, which is charged on the outstanding public debt.[7] The term dt indicates the instantaneous time variation.

The stochastic component is given by the driftless Brownian motion process σdz[8]. The parameter σ represents the instantaneous standard deviation of the Brownian motion, and the term dz is the Brownian motion variation, which is so characterized:

(2) $$dz = \chi\sqrt{dt},$$

where χ is a random variable which is independently, identically and normally distributed, with 0 mean and variance equal to 1.

2.1 Fiscal and monetary orthodoxy

We identify EMU *fiscal orthodoxy* as member governments' commitment to stabilising public debt (as a ratio to GDP unless otherwise stated) by their own means (i.e. to the exclusion of fiscal transfers, debt sharing, or bailout, by any other member government, f_t

[7] For simplicity we abstract from the inflation rate, which may be regarded as negligibly low. Hence it is immaterial whether r and g are computed in real or nominal terms.
8 Some target-zone models consider instead a Brownian motion process with drift (e.g. Krugman and Rotemberg 1992). In this context, the drift would not add further insights, and we can therefore avoid its use here.

= 0). Moreover, government should also aim at the Maastricht official target of 60%. For this reason, and others that will be introduced below, it is thus convenient to think of b_t as the excess of the debt level over the official debt target at any moment *t*.

Equation (1) also displays two important interaction channels with monetary policy represented by the monetisation rate of public debt m_t, and the interest rate r_t on public debt. Monetisation can take various forms, some of which will be treated in section 3.1; for the time being, by this term we mean any intervention of the central bank implying money creation that supports the debt stabilisation effort of the government. We identify EMU *monetary orthodoxy* by the prohibition of monetisation in any form, $m_t = 0$.

As to the interest rate, it may be thought of as being composed by a riskless reference interest rate i_t, which is the policy instrument in the hands of the central bank, and by a risk premium RP_t, which is country-specific. We shall consider the policy rate as an exogenous variable amenable to spot changes by the central bank (hence the time index will be dropped). The specification of the risk premium will be introduced below.

Consequently the commitment to the stability of public debt, in compliance with the fiscal and monetary orthodoxies, requires that at any point time E(db/dt)= 0.[9] According to equations (1) and (2), governments should aim at the primary balance given by

(3) $$\tilde{s}_t^* = (i + RP_t - g_t)b_t$$

so that subsequently public debt may only be moved away by the stochastic amount:

(4) $$\frac{db_t}{dt} = \sigma dz/dt.$$

Equation (3) shows that whenever $(i + RP_t - g_t)b_t > 0$ a primary surplus $\tilde{s}_t^* > 0$ is necessary. It measures the "fiscal effort" necessary to achieve debt stabilisation (Bohn 1995).

2.2 The fiscal target zone

Is the commitment represented by equation (3) *credible*? By this term we mean that the commitment should pass a test of government's cost-benefit trade-off, of which investors are aware. An instance is provided by the literature on sovereign debt crises. A general feature of this literature is that governments seek to strike a balance between the benefits of debt stability, such as access to markets at easier terms, with its costs encapsulated into the fiscal effort necessary for debt stability – our target primary surplus $\tilde{s}_t^*$ (Buiter and Rahbari 2013, De Grauwe 2012, Ghosh et al. 2013, Gros 2012, Tamborini

[9] For precision, according to the Fiscal Compact undersigned in 2012, as outstanding debt rises above 60% (b_t > 0), the government would be required to reduce debt by 1/20th of the excess per year. Technically, this requirement would introduce a correction mechanism in the debt process, which would complexify the model with the only tangible implication of a target primary surplus greater than in equation (3). In order to keep the model manageable, we disregard this requirement. We may add that, as a matter of fact, it has never been enforced, and it will probably not be enforced in the near future.

2015). In fact, greater fiscal effort imposes either higher taxes and/or lower expenditures with a variety of economic, social and political consequences. Since we shall consider unwillingness to stabilise debt as a breakup of EMU membership,[10] the government should assess the EMU specific benefits *vis-à-vis* the costs of breakup, which may raise the limit of fiscal effort significantly in comparison with stand-alone countries. Here we need not go into the details of specific cost-benefit calculations, but we simply draw on the general result in this literature about the existence of a threshold of the target primary surplus (3), let it be $\bar{s}$, above which the costs of debt stabilisation exceed the benefits. Therefore, equation (3) should be complemented with the upper *feasibility constraint*:

(5) $\tilde{s}_t^* \leq \bar{s}$.

Negative shocks to debt, or favourable conditions of the interest-growth gap, may allow the government to target primary deficits $\tilde{s}_t^* < 0$ while keeping debt stable. Nonetheless, specific to the EMU is the existence of the deficit cap of 3% of GDP. This has been further translated into a limit to the "structural" primary balance which, according to the Medium Term Objectives in the Preventing Arm of the Stability and Growth Pact, should be in balance or in slight surplus. This objective also sets a lower *regulatory constraint* that we can write as:

(6) $\tilde{s}_t^* \geq 0$.

At $\tilde{s}_t^* = 0$, favourable events should entirely go to debt reduction.[11]

These constraints set our model within the general framework of TZ models. By controlling the primary surplus, the government intervenes to stabilise public debt after random shocks *within* the TZ. However, the upper and lower bound of our TZ are different in nature. The lower bound is set by regulation, and each government is obliged to respect it. The upper bound is chosen by the government in violation of the unconditional commitment to debt stabilisation. As $\tilde{s}_t^*$ is at the upper bound, the government gives up its commitment to servicing debt, which amounts to the breakup of EMU membership, in analogy with the decision of abandoning an exchange-rate agreement. Breakup at the lower bound is due to violation of the Excess Deficit Procedure. Breakup at the upper bound is due to a sovereign debt crisis.

The existence of the upper bound of the TZ has an important implication for the risk premium that the government should pay on its debt, $RP_t b_t$. The risk premium may have a number of determinants. Here we focus on one single dimension, namely default risk, and

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[10] As it was foreshadowed in the Greek debt crisis.

[11] For precision, the structural primary balance depurates the actual primary balance from its cyclical component and transitory components. We cannot introduce this detail here; however, as will be seen, the model will accommodate the split of the growth rate of GDP in equation (3) between its structural and cyclical component.

drawing on the TZ dynamic models we assume that the risk premium has two components, which are encompassed in the following formulation:

(7) $RP_t = \rho + \alpha E \frac{d(\tilde{s}*_t)/b_t}{dt}$

The first one, denoted by ρ, depends on the size of public debt at any moment *t*, so that it can be defined as fundamentals-driven. This is activated as $b_t > 0$, i.e. debt exceeds the EMU target.[12] The second component is a typical "self-fulfilling" process of market expectations, or "positive feedback" mechanism, which plays a crucial role in the literature on sovereign debt crises discussed above, and is also a customary feature of many financial variables, not only interest rates, but also exchange rates and inflation rates.[13] As debt is shocked away from b_t, and investors expect the target primary surplus to increase and move closer to its upper bound where the government may give up stabilisation and opt for default, they also charge a higher risk premium. A higher risk premium raises the primary surplus that is necessary for debt stability, which in fact moves closer to its upper bound and justifies a higher risk premium, and so on, creating a destabilising spiral.[14] The parameter α weighs the impact of this process on the risk premium.

Note that indirectly, through the determination of $\tilde{s}_t^*$, the risk premium is sensitive to the institutional environment where governments operate, namely its extent of fiscal and monetary orthodoxy. This point has been raised by the well-known paper by De Grauwe (2012) comparing the higher risk premia of EMU countries relative to non-EMU countries with similar debt stocks but backed by the central bank as lender of last resort. It will also play a key role in the development of our model.

At the same time, the expectations about the dynamics of the primary surplus create another critical feedback effect on the fiscal effort equation (3) through the growth rate of GDP. The impact of fiscal manoeuvres on GDP are matter of long-lived research around the so-called "fiscal multipliers". The implementation of austerity in the EMU in view of fiscal consolidation has spurred a new wave of controversies. If a restrictive fiscal stance

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[12] Alcidi and Gros (2018), IMF (2011), and European Commission (2014) suggest that the risk premium increases when the public debt-to-GDP ratio exceeds a given threshold which is assumed to be risk free. The European Commission, referring to the European countries, finds a 0.03% increase in the risk premium, the IMF (having in mind mostly emerging countries) finds a 0.04% increase, for any percentage point of the public debt-to-GDP ratio exceeding 60%.

[13] An example relative to exchange rates is given by Krugman (1979), where the current value of the exchange rate also depends on its expected change. The case of the inflation rate is well represented by Barro and Gordon (1983) and the use that in that article is made of the Phillips curve, where the current inflation rate also depends on the expected inflation rate for the future.

[14] The search for the distinction between fundamental and non-fundamental determinants of spreads during the Euro Zone sovereign debt crisis has prompted a whole strand of empirical studies (see, among others, Caceres et al. 2010, Favero and Missale 2011, De Grauwe and Ji 2013a, Passamani et al. 2015, Gödl and Kleinert 2016). De Grauwe and Ji (2013a), and Passamani et al. (2015) have shown that the widening of spreads in the Euro Zone was also driven by mounting expectations of unsustainable fiscal efforts.

$\tilde{s}_t^* > 0$ has a "Keynesian" effect and depresses growth, then equation (3) shows a self-defeating effect triggering a vicious circle. However, a strand of literature (Giavazzi and Pagano 1990, Alesina and Perotti 1997, Alesina and Ardagna 2010) argues that if the *expected* fiscal restriction is well designed, e.g. cutting expenditures instead of raising taxes, the fiscal multiplier may be negligible or even change sign. In order to take this issue into account in a tractable manner, let us split the current growth rate into a structural component $\bar{g}$, independent of fiscal and monetary contingent stances, and a cyclical component sensitive to the expected dynamics of the fiscal stance, $\phi E d(\tilde{s}_t^*)/dt$, where ϕ is the fiscal multiplier ($\phi < 0$ denotes a Keynesian multiplier). Hence the growth-debt interaction results to be given by:

(8) $g_t = \bar{g} + \phi E \frac{d(\tilde{s}_t^*)/b_t}{dt}$

Therefore, using equations (7) and (8), the target primary surplus (3) can be rewritten:

(9) $\tilde{s}_t^* = \delta b_t + \beta E \frac{d(\tilde{s}_t^*)}{dt}$

where $\delta = (i + \rho - \bar{g})$ is the structural interest-growth gap, which we treat as an exogenous parameter, and $\beta = \alpha - \phi$ encompasses the two critical expectational effects discussed above. The parameter δ plays a critical role as long as it remains positive, which we assume as the normal condition.[15] A negative fiscal multiplier determines $\beta > 0$, so that the vicious circle of self-defeating fiscal consolidation is enhanced, accelerating the trajectory towards the upper bound of the primary surplus. A positive fiscal multiplier may instead mitigate the vicious circle or even reverse it (if $\beta < 0$).

To summarise, our fiscal TZ model is composed by the following equations:[16]

(9) $\tilde{s}_t^* = \delta b_t + \beta E \frac{d(\tilde{s}_t^*)}{dt}$

(4) $\frac{db_t}{dt} = \sigma dz/dt$

(5) $\tilde{s}_t^* \leq \bar{s}$.

(6) $\tilde{s}_t^* \geq 0$

These equations imply a lower and upper bound of debt, too. In fact, as $\tilde{s}_t^*$ hits the bounds of the TZ, then $E\frac{d(\tilde{s}_t^*)}{dt} = 0$; therefore, at $\tilde{s}_t^* = 0$ debt should be $b_t = 0$, i.e. at the official target of 60% of GDP, whereas at $\tilde{s}_t^* = \bar{s}$ debt cannot exceed $b_t = \bar{b} = \bar{s}/\delta$. Hence

15 The case $\delta \leq 0$ may stylise a scenario with zero policy rate and positive, although low (zero) nominal growth which fits the current situation in the EMU. The effect would be that the problem of stabilisation vanishes. The government may stay passive and keep the primary surplus in balance, or enjoy space for deficits, for any level to where shocks may bring public debt b_t since $\delta \leq 0$ ensures that debt will not grow ($\delta = 0$) or will be self-reducing over time ($\delta < 0$). In fact, Blanchard et al. (2019) argue for the reconsideration of the issue of debt sustainability when the interest-growth gap is zero or negative.

16 This combination of a stochastic fundamental and an expectational component is analogous to the standard formulation of exchange-rate target zone models, such as Krugman (1991), Krugman and Rotemberg (1992), Bertola and Caballero (1992)

the shock-absorption capacity of the government depends positively on its upper bound to fiscal effort and negatively on the structural interest-growth gap. Consequently, public debt can fluctuate within a band centred on $\bar{b}/2$, where the crucial role is played by the expectational component of $\tilde{s}_t^*$, which reacts to the extent the government is expected to be able to accommodate debt shocks or not, and impinges upon non-fundamental risk premium and growth.

2.3. The model solutions

Preliminarily, let us consider equation (9) when its expectation component is muted, i.e. if the government's unconditional commitment to stabilising debt for any amount of the shock would be taken at face value. As a result, $\tilde{s}_t^*$ would *linearly* increase with the level of debt (see Figure 2, schedule SS). This will provide a useful benchmark in the subsequent analysis.

[Figure 2]

The target primary surplus (9) is a first-order differential equation, which, given (4), (5) and (6), has the general solution (see the Appendix A1 for derivation):

(10) $$\tilde{s}_t^* = \delta b_t + A_1 e^{\lambda_1 b_t} + A_2 e^{\lambda_2 b_t}$$
$$\lambda_{1,2} = \pm\sqrt{2/\beta\sigma^2}$$

The parameters $A_{1,2}$ are indeterminate, and in order to determine them and close the model, it is necessary to analyse the behaviour of the function as $\tilde{s}_t^*$ approaches its upper and lower bounds.

We treat the behaviour of the system at the lower bound straightforwardly, assuming that the government is always compliant with the zero primary-balance rule. Hence for (10) to be zero at $b_t = 0$, it should hold that $A_2 = -A_1$, so that

(11) $$\begin{cases} \tilde{s}_t^* = \delta b_t + A(e^{\lambda b_t} - e^{-\lambda b_t}) & b_t \geq 0 \\ 0 \text{ otherwise} & \end{cases}$$

To study the behaviour of the system at the upper bound, we shall follow the solution method of TZ "realignments" presented by Bertola and Caballero (1992). This is based on an arbitrage argument. The value of the target primary surplus $\tilde{s}^*(\bar{b}) = \bar{s}$ has to be equal to the expected one resulting from the probabilities of two different events that may take place when $\tilde{s}_t^*$ reaches $\bar{s}$.

With probability p, public debt is allowed to jump upwards above $\bar{b}$ by say the amount ε^u. This event, therefore, is virtually equivalent to moving up to the centre of a higher debt TZ $\in [\bar{b}\ ,\ 2\varepsilon^u]$ that would require a target primary surplus larger than $\bar{s}$. Yet the government is unwilling to sustain such a larger primary surplus and will leave its debt service unsatisfied. Hence, in our context, ε^u can be interpreted as the "haircut" that investors expect in case of breakup.

With complementary probability (1-p), debt will not be allowed to increase. The stabilizing intervention – whatever it may be as will be discussed subsequently – is such as to remain at $\bar{b}$ or move below by say the amount ε^d to the centre of the debt TZ $\in [\bar{b} - 2\varepsilon^d, \bar{b}\,]$ where the government is still willing to stabilise debt.

As we show in Appendix A2, the value of A consistent with the above no-arbitrage condition is:

(12) $A = \delta[p(\varepsilon^u + \varepsilon^d) - \varepsilon^d](e^{\lambda\bar{b}/2} - e^{-\lambda\bar{b}/2})^{-1}$

Substituting (12) into (11) yields the explicit form of the function of the target primary surplus, used to draw Figure 2 for hypothetical parameter values.

2.4 Divorce vs. honeymoon

Probability p can be interpreted as a measure of distrust in the commitment to unconditional debt stabilisation, and hence breakup of the EMU. It plays a crucial role in the dynamic evolution of the system by conditioning the sign of the parameter A. As can be seen from (12),

$$A \gtrless 0 \text{ iff } p \gtrless \frac{\varepsilon^d}{\varepsilon^u + \varepsilon^d} \equiv p*$$

We denote by p^* the critical level of p such that A = 0, yielding the linear case of the SS function in Figure 2. This critical p^* in turn depends on debt behaviour expected at the upper bound of the TZ. If debt is expected to move up or down by the same amount, then p^* = 1/2.[17] To the extent that $\varepsilon^u > \varepsilon^d$, i. e. the more public debt is expected to increase above its sustainable upper bound in case of breakup, p^* is reduced, meaning that also the chances of breakup should be lower in order to keep the system on the linear track. Yet, as long as p is independent of the other parameters, $p = p^*$ may only materialise by chance.

If $p > p^*$, i. e. there is high distrust in the no-breakup intervention, then A > 0, and the ensuing function, labelled *SD* in Figure 2, becomes convex. The consequence is that for any level of debt, *SD* bends above and to left of the linear *SS.* The economic intuition is that as $\tilde{s}_t^*$ gets closer to the upper bound, the anticipation of the non-feasibility of the fiscal consolidation that would be necessary to guarantee stability raises the risk premium to be paid by the government, which accelerates the trajectory towards the upper bound. In other words, owing to the expectation component of the target primary surplus, the shock-absorption capacity of the government is reduced ($b_T^D < \bar{b}$ in Figure 2), or shocks lead faster to breakup. This scenario has been dubbed "*divorce*" in the TZ literature.

The extent of the divorce effect depends on the curvature of the *SD* function, which increases with *A.* As a limit case, with integral EMU orthodoxy, investors know for sure (p

17 Bertola and Caballero (1992) assume the probability of a symmetric upward or downward jump. See also Della Posta (2018a)

= 1) that at the upper bound there will be no resources needed to revert public debt towards the centre of the band ($\varepsilon^d = 0$). Consequently,

(13) $$A = \delta \frac{\varepsilon^u}{2} (e^{\lambda \bar{b}/2} - e^{-\lambda \bar{b}/2})^{-1} > 0$$

which generates the schedule *SD'* in Figure 2. Note that anyway $\varepsilon^d = 0$ is sufficient for $A > 0$ for any *p.*

This outcome of the model may vindicate the criticisms about the unintended consequences of the EMU twin orthodoxies in combination with market discipline (see also section 3.3). Defenders maintain that the perception of the *de facto* demise of neither monetary nor fiscal bailout of insolvent countries prompted fiscal laxity and market undervaluation of default risks, thus paving the way to the sovereign debt crisis. Critics argue that the neither-nor clause may turn itself into a threat to the EMU stability and integrity.[18] Indeed, our model shows that if investors understand that countries do have a limit to their sustainable fiscal consolidation, and firmly believe in the neither-nor clause, then the system is less resilient to sovereign debt shocks and prone to breakup threats.[19]

If $p < p^*$, i.e. higher confidence arises in the no-breakup intervention, then $A < 0$, and the opposite scenario occurs, called "*honeymoon*". The function of the target primary surplus, labelled *SH* in Figure 2, becomes concave and bends below and to the right of *SS*, meaning that the shock-absorption capacity of the government is increased as measured by the difference between b_T^H, the debt absorbed by the government at the moment *T* when *SH* crosses the upper bound, and $\bar{b}$. In fact, now the relative greater confidence in sufficient resources to absorb the shock within the government's upper bound reduces the risk premium and *decelerates* the run-up of the target primary surplus towards the upper bound.

This approach to TZ modelling has the merit of explaining transitions from "honeymoon" to "divorce" scenarios, and return, that may be hard to explain on the basis of simple fundamentalist models. An important driver of transitions are sentiments of trust/distrust in the irreversibility of the system captured by the probability *p*. Volatility of these sentiments may account for the sudden and abrupt transitions that we have witnessed in the two decades of life of the EMU sovereign debt markets, such as the 2010-11 upsurge of spreads after a decade of tranquillity (both of which phenomena may be judged inconsistent with fundamentals alone), and the rapid reversion after the

[18] As a "field experiment" of this view, the notorious "Deauville walk" is often cited, when, on October 19, 2010, Nicolas Sarkozy and Angela Merkel decided in a private talk the future involvement of the private sector in the debt restructuring of EMU member states applying for financial assistance. The event concurred to the sudden diffusion and acceleration of the sovereign debt crisis across the board. For detailed rendition and discussion see e.g. Brunnermeier et al. (2016), ch. 2.

[19] As testified by the evidence on "redenomination risk" found in the determinants of sovereign risk during the crisis (Di Cesare et al. 2012, De Santis 2015).

celebrated "whatever-it-takes" speech by the ECB's President Mario Draghi. On the other hand, trust and distrust may not be totally unrelated to real factors. Though we treat *p* as exogenous, our model highlights a relationship with the institutional design of the EMU, since investors figure out what the behaviour of the system may be at the upper bound of the fiscal TZ taking into account whether or not enough resources may be deployed to sustain the no-breakup of the EMU.[20] In the subsequent part of the paper we shall address the issue of modifications of the EMU setup apt to sustain trust in its irreversibility.

3. Relaxing the twin orthodoxies

The shock-absorption capacity of single governments, however strong it may be, remains limited. Unusual tail events may suddenly push towards divorce for single governments or *for the system as a whole*, as was indeed the case in the aftermath of the global financial crisis and of the outbreak of the pandemic. When these events happen, and *they can happen*, the EMU Trilemma materialises, and the imperative of the euro irreversibility is in jeopardy.[21]

Our aim now is to show that the preservation of the EMU can be achieved by relaxing one between monetary and fiscal orthodoxy, or both. We complete the analytical solutions of the model treating the case in which the commitment to debt stabilisation is credible, in the sense that investors anticipate that shocks will be fully accommodated, and debt stabilised, *within the government's feasibility constraint* (namely $\tilde{s}_t^* \leq \bar{s}$).[22] We shall see that this creates the condition for the honeymoon effect.

3.1 Relaxing monetary orthodoxy

Monetary policy can influence the dynamic evolution of the EMU target zone presented above through different channels. The first one is the "conventional" interest-rate policy, that is introduced in the model through the risk-free policy rate *i* in the parameter δ. EMU monetary orthodoxy prescribes that the policy rate is exclusively targeted to price stability, which makes it fully exogenous to the problem of governments' debt control. The case of δ > 0 assumed so far and in Figure 2 hardens the problem.

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[20] This point, the critical role of resources necessary to "defend" the upper bound, is similar to the one maintained by Krugman and Rotemberg (1990) in the case of an exchange-rate TZ with limited reserves.

[21] This is in line with the conclusions reached in the literature on anti-inflationary credibility as to the opposition between rules and discretion: while the seminal deterministic models by Kydland and Prescott (1977) and Barro and Gordon (1984) concluded that rules are Pareto superior to discretion, the introduction of uncertainty, namely the possibility that the economic system is hit by stochastic shocks, led to deny such a conclusion (Lohman 1992,).

[22] Note that credibility is assessed not against the unconditional commitment dictated by fiscal orthodoxy, but against the actual stabilization capacity of the government. The upper bound of the target primary surplus is still in place, and investors are aware of it.

This hurdle can be lowered either because the "divine coincidence" of below-target inflation allows the central bank to reduce the policy rate, as has been the case for the last ten years (Lane 2020), or because the central bank decides a cooperative policy for the debt control problem (e.g. Mason and Jayadev 2018, Bonatti et al. 2020). In either case, the conventional policy faces the well-known zero lower bound of the policy rate (though in practice central banks have the power to achieve negative interest rates in the money market: Lane 2020).

As long as $\delta > 0$, in alternative, or addition, to conventional interest-rate policy, a central bank in a stand-alone country has virtually an unlimited liquidity potential and it is, therefore, always able to backup the sovereign debt as lender of last resort (LLR). As suggested by De Grauwe (2012) and De Grauwe and Ji (2013a, 2013b), this option, beyond its actual activation, has proved able to stabilise the sovereign debt markets, and financial markets more generally, in the non-EMU countries. Analogous result has been obtained by the change of attitude towards direct financial stabilisation undertaken by the ECB since 2012. An important difference with interest-rate policy is that the LLR interventions are once and for all and targeted to a specific event.[23]

This can be, and has been, done in various forms: (i) creation of Treasury's monetary balances (an instance of "helicopter money")[24], (ii) purchases of new debt created by the shock, (iii) purchases of outstanding debt on the secondary market, as currently practiced by the ECB under the Asset Purchases Programme and the Pandemic Emergency Purchases Programme (PEPP).

In terms of our model, key to preventing the system breakup is investors' expectation of the central bank to provide enough liquidity to absorb the *stochastic* shocks hitting public debt, complementing or substituting the fiscal effort necessary for debt stability, should it exceed the maximum level $\bar{s}$ that the country can withstand. The effect can easily be seen by means of the conditions of divorce vs. honeymoon presented in section 2.5 and setting $\varepsilon^u = 0$. The result is that $A < 0$, i.e. the condition for the *honeymoon scenario*, for any probability p assigned by investors to the alternative event of breakup.

However, it may be desirable that the LLR intervention is minimised, that is to say, necessary and sufficient to absorb just the excess debt that is not sustainable by the government ($\varepsilon^d \to 0$). The solution technique consists of the "smooth pasting" condition, that was also used to close the first generation of TZ models launched by Krugman (1991), which mathematically calls for finding the tangency condition between the equation of the target primary surplus 0 and the upper bound $\bar{s}$ at the instant T when the latter is hit.

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[23] Usually, increasing liquidity supply goes with lowering the policy rate. Yet the so-called "quantitative easing" polices have been activated by major central banks after reaching the zero lower bound of the policy rate.

[24] For the current revival of the "helicopter money" idea see e.g Galì (2020), and Cochrane (2020).

To understand to role of the LLR intervention, let us first consider the basic case (i) mentioned above, let us name it "pure monetisation", which has a straightforward correspondence with the variable m_t in the debt equation (1). Consequently, we can write:

(14) $$\tilde{s}_t^* = -m_t + \delta b_t + A(e^{\lambda b_t} - e^{-\lambda b_t})$$

Denoting with b_T^{SP} the level of debt at the upper bound, at point in time T, the first order condition for smooth pasting is

$$\frac{ds_T}{db_T^{SP}} = \delta + \lambda A(e^{\lambda b_T^{SP}} - e^{-\lambda b_T^{SP}}) = 0$$

which yields the value of A

(15) $$A = -\frac{\delta}{\lambda}\left(e^{\lambda b_T^{SP}} - e^{-\lambda b_T^{SP}}\right)^{-1} < 0$$

$A < 0$ ensures the honeymoon effect. The resulting concave function $\tilde{s}^*(b_t)$ is plotted as *SP* in Figure 3.

[Figure 3]

Then we can establish that the target primary surplus at the upper bound has value:

(16) $$\tilde{s}_T^* = \bar{s} = -m_T + \delta(b_T^{SP} - 1/\lambda)$$

The implied LLR intervention is therefore,

(17) $$m_T = \delta(b_T^{SP} - 1/\lambda) - \bar{s}$$

i.e. the central bank should stand ready to monetise any debt shock in excess of the maximal shock-absorption capacity of the government, b_T^{SP}. To pin down the value of b_T^{SP}, we can recall that $\bar{s} = -m_T + \delta\bar{b}$. The result is, therefore:

(18) $$b_T^{SP} - \bar{b} = 1/\lambda > 0$$

which measures the honeymoon effect. Note that its extent is only determined by $\lambda = \sqrt{2/\beta\sigma^2}$, i.e. by the exogenous parameters that govern the process of $\tilde{s}_t^*$.

We can thus appreciate two important features that characterise this institutional setup. First, thanks to the honeymoon effect (see section 2.5), the resilience of the system is enhanced. To the extent that investors anticipate the LLR intervention, the non-fundamental risk premium driven by expectations of breakup is curbed all along the trajectory of the target primary surplus also in case of within-the-band shocks (the *SP* curve in Figure 3), *though the central bank does not intervene on these shocks*. Since the LLR intervention is *erga omnes*, we may say that the honeymoon effect translates itself into a "system resilience premium" embodied by the sovereign debt market as a whole.[25] Second, monetary and fiscal debt stabilisation are *complements*: in the sense that the commitment to LLR, *conditional* on the government's full fiscal effort, *increases* the shock-

[25] This would make the sovereign debt of EMU members more similar to that of stand-alone countries according to the distinction drawn by De Grauwe (2012)

absorption capacity of the government, and *reduces* the potential exposure of the central bank.

We can now consider the other two types of LLR interventions, consisting of purchases of sovereign bonds either at issuance or in the secondary market. Though often regarded as equivalent to pure monetisation, they are not. For these interventions, in different ways, boil down to a debt swap from the market to the central bank. This fact has implications that should be taken into account which modify the picture presented above.

The first issue is whether the central bank's share of public debt reduces or not the government's total exposure b_t. The answer may be affirmative in a stand-alone country, where assets and liabilities across state compartments cancel out and the central bank fully pays interests back to the government. Whether the same applies to the EMU is more controversial because of the different capital keys of member countries in the ECB's capital (De Grauwe and Ji 2013b). Indeed, the EMU fiscal rules are targeted to the total outstanding debt regardless of the share held by the Eurosystem. The second issue concerns the determination of the interest rate and the relevant risk premium. Does the debt swap to the central bank make any difference? The presumption is that it does, otherwise there would be no point in doing the swap. [26]

Since the ECB is not allowed to buy sovereign bonds at issuance, let us consider the case of purchases of outstanding debt. These, at any point in time, reduce b_t by the amount b_t^{CB} leaving the difference on the market. Let us assume that the central bank's holdings do not reduce the total debt to be targeted by the government, but with its purchases it pushes the interest rate towards the risk free policy rate i. Consider now this intervention at the upper bound by the amount b_T^{CB} which leaves $b_T^{SP} - b_T^{CB}$ on the market, weighed by $\delta = i + \rho - \bar{g}$, while b_T^{CB} , weighed by $\delta' = i - \bar{g}$, is in the hands of the central bank. As a result,

(19) $\tilde{s}_T^* = \bar{s} = -\rho b_T^{CB} + \delta(b_T^{SP} - 1/\lambda)$

By comparing equations (16) and (19) it turns out that $\rho b_T^{CB} = m_T$, and, since $\rho < 1$, then $b_T^{CB} > m_T$. This result has two implications which help understanding and assessing the ECB's asset purchases programmes deployed since 2015 (further discussion in section 3.3). First, the honeymoon effect is still present as in the case of monetisation. Second, the government's debt relief at the margin, however, is limited to the resulting "discount" on the fundamental risk premium. Consequently, the required amount of debt purchases

[26] A rationale may be that the central bank has greater loss-absorption capacity than private investors, and hence can contribute to reduce the risk premium paid by the government. According to some authors (e.g. De Grauwe and Ji 2013b), the central bank has infinite loss-absorption capacity since, having no creditors, it cannot go bankrupt. The equivalence between purchases of debt and pure monetisation would occur with full cancellation of debt and interests owed to the central bank, which has been put forward recently (e.g. Becchetti and Scaramozzino 2020).

should be (much) larger than pure monetisation. It would be possible to argue that this is quite a significant to be paid to the prohibition of pure monetisation.

We have seen that in order for the EMU irreversibility to be fully credible, the ECB's commitment as LLR ought to be unlimited. We would move therefore into a system of full insurance of investors by the central bank against governments' defection on the commitment to debt stability, since any shock beyond the absorption capacity of governments would be absorbed by the central bank. The next question is the extent to which this system is feasible, and to this we shall turn subsequently.

3.2. Relaxing fiscal orthodoxy

In the case in which monetary policy is not available (for example because there may be the risk of inflation, or because of institutional constraints – as it might be the case for the ECB), and/or in order to reduce its contribution and avoid the risk of monetary instability and inflation (if any) there is yet another possibility, namely stabilizing national public debt thanks to a 'federal' fiscal support (f_t in equation (1)). Equation (14), then, becomes:

(20) $\tilde{s}^*(b_t) = -m_t - f_t + \delta b_t + A(e^{\lambda b_t} - e^{-\lambda b_t})$

A prominent, and unprecedented, example is "Next Generation EU" (NGEU), the anti-pandemic plan elaborated by the European Commission and approved by the European Council in July 2020. The plan allocates to Member States collective resources explicitly targeted to public expenditures in view of stabilisation and recovery of the economies shattered by the pandemic.[27] As such, the plan complements the already huge expansion of public debts generated by the emergency plans at the national level. From this point of view, NGEU acts as backstop to the governments' shock-absorption capacity analogously to the monetary interventions examined in the previous paragraph. As is clear from equation (20), analytically, the same results as above apply.

In particular, the analogy also regards the government's liability after the intervention. NGEU resources consist of a grant component γ and a loan component $(1-\gamma)$. The grant component means that no liability is left after the intervention, which corresponds to the case of pure monetisation above, whereas the loan component entails a liability towards the EMU at a concessional rate. Let the latter be the risk-free rate i, and $\delta' = i - \bar{g}$. Therefore, the fiscal intervention at the upper bound of the TZ is:

(21) $\tilde{s}^*_T = \bar{s} = -f_T(\gamma - \delta'(1-\gamma)) + \delta(b^{SP}_T - 1/\lambda)$

Writing f_T as the complement to the government's maximal shock absorption, and recalling from (18) that $b^{SP}_T = \bar{b}_T + 1/\lambda$, we can see that:

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[27] In the case of NGEU, f_t should be considered net of the country's own share in the creation of the collective fund.

(22) $$f_T = \frac{\delta(\bar{b}_T+1/\lambda)-\bar{s}}{\gamma(1+\delta')-\delta'}$$

that is to say, f_T has to be larger, the smaller is the grant component γ.

Another important point highlighted by equation (20) is that *the monetary and the fiscal interventions are complements*. Activating both reduces the extent of each. As argued in the Introduction, this is one of the key innovations of the overall anti-pandemic policy package of the EMU in comparison with the response to the crisis of the 2010s when the whole burden of the integrity of the EMU was left on the shoulders of the ECB, with heavier strain of monetary orthodoxy *vis-à-vis* the tightening of fiscal orthodoxy. [28]

3.3. Moral hazard and EMU irreversibility

As said above, the "smooth pasting" solution in our model is equivalent to an insurance on investments in sovereign bonds, and any insurance scheme brings the moral hazard issue with itself. Minimisation of moral hazard has been central in the design of the rules of the EMU (e.g. Brunnermeier et al. 2016, ch. 6, Gros 2021), and it remains central in the debate about the reforms of the rules (e.g. CEPR 2016, Delatte et al. 2017, European Fiscal Board 2019). Discussion of such a complex issue is beyond our scope here. However, a few considerations are in order.

The first is that our model supports the view that the protective belt of the monetary and fiscal orthodoxies against moral hazard may bring benefits but also costs for the EMU. If the benefits come from enforcing fiscal discipline of national governments, the costs arise from the loss of resilience of the system as a whole in the face of large shocks. The credibility of the imperative of EMU irreversibility cannot be entirely left on the shoulders of governments' commitment to fiscal discipline and debt sustainability. It should be acknowledged that governments, especially those under democratic scrutiny in complex developed societies, face limits to the fiscal effort they can bear in order to keep public debt stable in the event of large shocks. These *may happen*, making fiscal effort unsustainable. A widely shared lesson drawn from the crisis of the 2010s is that a wise institutional design should take these events into account and foresee appropriate instruments, instead of muddling through *ad hoc* arrangements afterwards (De Grauwe 2013, Gros 2014, Brunnermeier et al. 2016, chs. 6-7, CEPR 2016). A *Union's no-breakup mechanism* (monetary and/or fiscal) is also necessary.

In the second place, in the original conception of the EMU, monetary and fiscal orthodoxy curb moral hazard in cooperation with the so-called "market discipline", i.e. the alleged efficiency of financial markets in finding the "right price" of sovereign bonds. This presumption has seriously been weakened by the events leading to, and then

[28] We do not consider here other specific aspects of the fiscal intervention that differentiate it from monetary interventions, such as the possibility to target the resources to growth-enhancing expenditures.

boosting, the sovereign debt crisis. The distinction between fundamental and non-fundamental determinants of sovereign risk premia has become critical, both theoretically and empirically (Lane 2020, Schnabel 2020b). In line with this literature, our model, too, shows that the non-fundamental component of the risk premium may ignite the acceleration towards breakup.

More on normative grounds, monetary interventions aimed at the stabilisation of the sovereign debt market have been legitimised by the necessity to curb the non-fundamental component of widening risk premia, while being beneficial to the stability of the system as a whole and not just to single countries (Draghi 2012, Schnabel 2020a, 2020b). As we have seen, this is precisely the result of the investors' anticipation of a backstop to governments' shock-absorption capacity in the honeymoon scenario. Moreover, the honeymoon effect operates as a "system resilience premium" all the time even in the absence of direct intervention, as in fact happened with the ECB's announcement of the Outright Monetary Transactions.

This feature is particularly relevant in consideration of moral hazard. For the Union's no-breakup mechanism need be activated only "at the margin", the upper bound of the TZ, while the stabilisation of inframarginal shocks remains full responsibility of national governments. Moreover, we have seen that, at the margin too, the government is fully involved in the stabilisation effort by its own part, and this can be *larger if the no-break mechanism is in place*. This arrangement, where the conditionality of intervention concerns the country's (sustainable) involvement in the stabilisation, seems more effective than the more usual one where conditionality concerns debt restructuring (private sector involvement) and subsequent macroeconomic adjustment. In fact, the prospect of the private sector involvement is precisely the driver towards the divorce scenario, while the prospect of heavy macroeconomic adjustment raises the costs of compliance with EMU membership and lowers the upper bound of the TZ. Much of the painstaking management of the Greek crisis was due to major mistakes on these two issues.

It may be argued that the consistent application of the backstop mechanism underpinning the "smooth pasting" solution presupposes (i) the ability to discriminate between genuine unfavourable events and fiscal misbehaviour, and (ii) the identification of the actual (sustainable) shock-absorption capacity of the government. These two points recall the "illiquidity *vs.* insolvency" dilemma, which, most of the times, is a true dilemma that plagues the management of financial crises at the micro as well as at the macro level. Yet this awareness should not prevent the conception of a design that balances the risk of moral hazard of national governments with the risk of EMU breakup.

In this perspective, it should be recognised in the first place that the twin monetary and fiscal orthodoxies are strongly tilted towards the minimisation of the risk of moral hazard.

In doubt, presume fiscal misbehaviour and hidden adjustment capacity (Brunnermeier et al. 2016, p. 119). This attitude conditioned the early institutional response to the Europeanisation of the world crisis regarded as a collection of violations of the rules by single Member States without seeing the overall picture of existential threats to the EMU. By contrast, after some initial hesitation with automatic activation of the conventional mind set, the response to the pandemic crisis has taken the opposite road (Baldwin and Weder di Mauro 2020). As argued in the previous section, the joint relaxation of the twin orthodoxies has been an efficient strategy to reduce the strain on both. It is likely that this outcome has been made possible since the pandemic shock is more easily perceived as a symmetric, involuntary catastrophic event.

Looking ahead at the the post-pandemic EMU, other black swans may materialise, of more economic nature and less general involvement ex-ante, that have to be tackled to prevent general involvement ex-post. A system of pre-emptive controls of fiscal discipline, and debt sustainability, remains necessary (possibly better conceived than the present one: see e.g. European Fiscal Board 2019). However,

> for extreme adverse events, excessive emphasis on individual liability is counterproductive; in such circumstances the solidarity principle should dominate. The European community thus needs a discussion of the extent to which it is willing to assume tails risks for its members. A commonly acceptable cutoff needs to be identified, agreed upon, clearly communicated, and enforced in future crises (Brunnermeier et al. 2016, p. 117).

4. Concluding remarks

The key findings of our model of the EMU as a fiscal TZ, under monetary and fiscal orthodoxy, can be summarised as follows. First, debt stabilisation by means of exclusive fiscal discipline is costly, and most likely faces a feasibility constraint. Second, investors understand that governments can, at best, commit themselves to debt stabilisation within a band of fiscal sustainability. Hence setting to governments the unconditional commitment to debt stabilisation is non-credible as it may not pass the test of the feasibility constraint. Third, as investors anticipate that the upper bound of the band is not defendable, the system becomes more fragile in that self-fulfilling run-ups to the upper bound are triggered, smaller debt shocks can be absorbed by governments, and breakup becomes more likely.

EMU need be completed with monetary and/or fiscal emergency backstop to the irreversibility principle. Drawing on the target-zone literature, we have shown how these devices can be designed in a consistent manner that minimises their extension and mitigates the moral hazard concerns. The alternative to these devices is not retaining both the EMU irreversibility and the twin orthodoxies but reformulating the treaties with explicit and regulated exit procedures.

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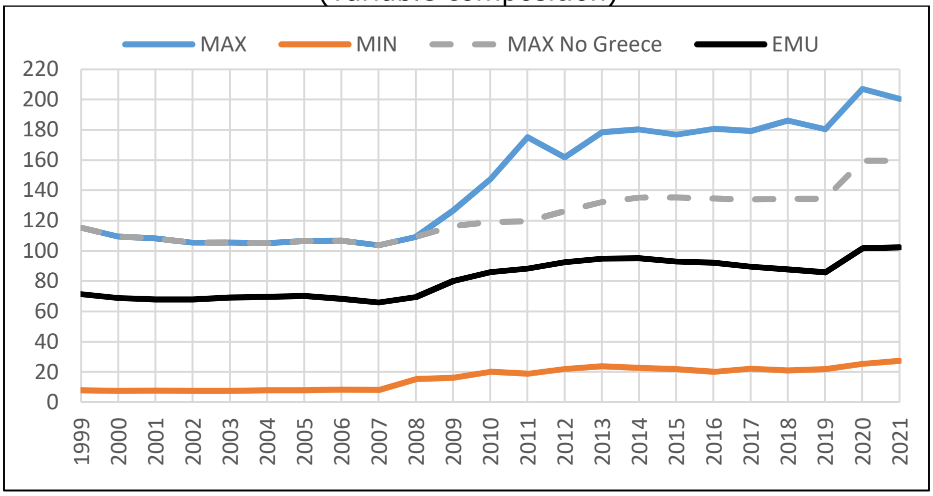
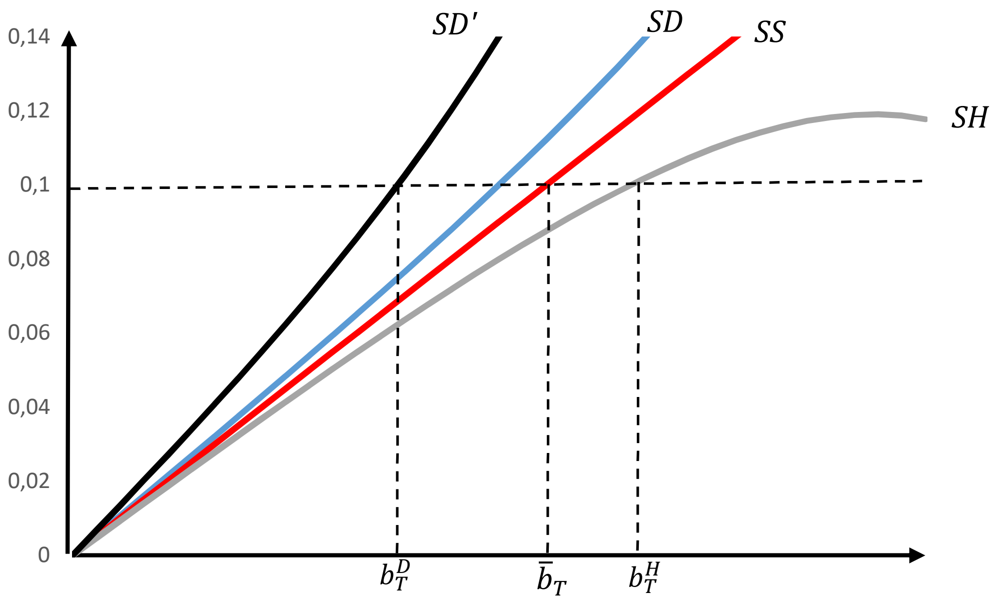
Figures

Figure 1. Band of the highest and lowest debt/GDP ratios in the EMU 1999-2021 (variable composition)



Source: Eurostat database AMECO

Figure 2. Divorce and honeymoon in the fiscal target zone



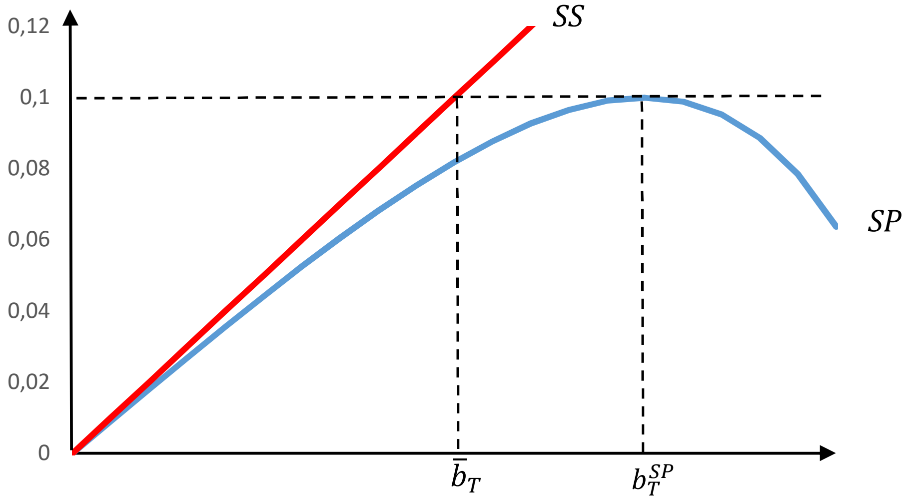
$\bar{s} = 0.1, \delta = 0.1, \beta = 0.5, \sigma^2 = 1, \bar{b} = 1$

SD: $\varepsilon^u = 0.2, \varepsilon^d = 0.2, p = 0.6$

SD': $\varepsilon^u = 0.2, \varepsilon^d = 0, p = 1$

SH: $\varepsilon^u = 0.2, \varepsilon^d = 0.2, p = 0.4$

Figure 3. Honeymoon and "smooth pasting"



$\bar{s}$ = 0.1, δ = 0.1, β = 0.5, σ^2 = 1, $\bar{b}$ = 1, 1/λ = 0.5

Appendix

A1. The general solution of the model

In order to solve equation (9),

(A1) $\tilde{s}_t^* = \delta b_t + \beta E \frac{d(\tilde{s}_t^*)}{dt}$

let us assume a generic functional form for $\tilde{s}_t^*$. The simplest functional form that we can assume is:

(A2) $\tilde{s}_t^* = f(b_t)$

We can now use this equation to calculate the expected variation of the target primary surplus. In order to do this, let us expand the function in a Taylor-type series, by calculating Ito's differential:

(A3) $d\tilde{s}_t^* = f'(b_t)E(db_t) + \frac{1}{2}f''(b_t)E(db_t)^2$

From the definition of db_t in (4), considering expected values, it turns out that $E(db_t)/dt = -\gamma$ and $E(db_t)^2 = \sigma^2 dt$. We obtain, then, Ito's Lemma:

(A4) $\frac{E(d\tilde{s}_t^*)}{d_t} = f'(b_t)(-\gamma) + \frac{1}{2}f''(b_t)\sigma^2$

By replacing (A4) into (A1) we have:

(A5) $\tilde{s}_t^* = f(b_t) = \delta b_t + \beta[f'(b_t)(-\gamma) + \frac{1}{2}f''(b_t)\sigma^2]$

This is a differential equation of the second order whose generic solution is of the class (Bertola and Caballero 1992, p.522):

(A6) $\tilde{s}_t^* = f(b_t) = \delta b_t + A_1 e^{\lambda_1 b_t} + A_2 e^{\lambda_2 b_t}$.

where $\lambda_{1,2} = \frac{-\gamma \pm \sqrt{\gamma + 2\sigma^2/\beta}}{\sigma^2}$ are the two roots of the characteristic equation.

A2. Honeymoon and divorce

In the text we have established that at the lower bound of the TZ, (A6) should be $f(0) = 0$, which requires $A_2 = -A_1 = A$. To study the conditions at the upper bound we apply the Bertola and Caballero (1992) methodology of TZ "realignments". To this end, we introduce the notation $f(b_t;\, c)$ where b_t refers to the current value taken by the fundamental, and c refers to the value of the centre of the band. For symmetric bands, (A6) becomes

(A7) $f(b_t;\, c) = \delta b_t + A(e^{\lambda(b_t - c)} - e^{-\lambda(b_t - c)})$

Recall that the current band of the target primary surplus is $\tilde{s}_t^* \in [0, \bar{s}]$ to which there corresponds the debt band $b_t \in [0, \bar{b}]$, centred on $c = \bar{b}/2$. Now let b_t hit the upper bound at time T, $b_T = \bar{b}$. Investors anticipate that with probability p, b_T will be let jump up by the amount ε^u; with probability $1 - p$, b_T will be moved down by the amount ε^d. Also, let

ε^u and ε^d be the centres of two new bands of dimension, respectively, $[\bar{b}, \bar{b} + 2\varepsilon^u]$ and $[\bar{b} - 2\varepsilon^d, \bar{b}]$. The solution is provided by the no-arbitrage condition such that

(A8) $$p\, f(\bar{b} + \varepsilon^u;\ \bar{b} + \varepsilon^u) + (1 - p) f(\bar{b} - \varepsilon^d;\ \bar{b} - \varepsilon^d) = f(\bar{b}; \bar{b}/2)$$

By applying (A7), we obtain:

(A9) $$p\delta(\bar{b} + \varepsilon^u) + (1 - p)\delta(\bar{b} - \varepsilon^d) = \delta\bar{b} + A(e^{\lambda\bar{b}/2} - e^{-\lambda\bar{b}/2})$$

which yields the value of A in equation (12) in the text.